

Combat-Related Pelvis Fractures in Nonsurvivors

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Background: The purpose of this study was to describe pelvic fractures and their associated injuries in service members who either died of wounds or were killed in action during Operation Iraqi Freedom and Operation Enduring Freedom and define any differences in associated injuries between penetrating versus blunt injury to the pelvis.

Methods: A review of all service members who sustained a pelvis fracture during Operation Iraqi Freedom and Operation Enduring Freedom in the year 2008 was performed. Data were recorded for analysis.

Results: One hundred four nonsurvivors were identified with pelvic fractures. Appropriate records, photos, and radiographs were available for 91, 70 were classified as "Not Survivable" (77%) and 21 "Potentially Survivable" (23%). Mechanisms of injury included 69 blast (76%), 14 gunshot wounds (15%), 4 motor vehicle accidents (4.5%), and 4 "other" (4.5%). Direct injury to the pelvis was penetrating in 60 (66%) and blunt in 31 (34%). Large pelvic vessel injury was observed more frequently in penetrating pelvic injuries (27%) than blunt injuries (3%). Hollow viscus abdominal injuries were more common in those with penetrating (57%) than blunt injuries (10%). There was an inverse relationship with intra-abdominal, solid organ injuries (blunt, 81%; penetrating, 55%). Head injuries were also more common in blunt pelvic injuries (blunt, 68%; penetrating, 45%), as were cardiopulmonary injuries (blunt, 84%, penetrating injuries, 57%).

Conclusions: Large pelvic vessel and hollow viscus injuries occur more frequently in penetrating combat-related pelvic fractures, whereas intra-abdominal solid organ, head, and cardiopulmonary injuries are more common in blunt pelvic injuries.

Key Words: Pelvis, Fractures, Combat, Wartime, Associated injuries, Mortality.

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The overall incidence of pelvic fractures is between 3% and 8% of all skeletal injuries seen in civilian trauma.^{1–3} Motor vehicle collisions (MVCs) remain the most common mechanism of injury followed by falls, motorcycle collisions, pedestrian versus auto, crush injuries, sports-related injuries, and assaults.^{1,3–8} Because of the high energy needed to create pelvic ring injuries, they are often associated with hemodynamic instability, chest trauma, head injuries, liver or spleen injuries, and long bone fractures.^{1,9–11} Multiple studies have shown an association between pelvic mortality rates and severity of fractures as well as other associated injuries.^{1,9,11,12} As a result, mortality rates in patients with pelvic ring injuries range from 3% to 20%.^{1,2,7,13–17}

It has been suggested that battlefield injuries are often the result of higher energy mechanisms of injury than civilian trauma and are often associated with extensive associated injuries.^{18,19} However, little data are available on wartime pelvic fractures, associated injuries, and their associated mortality. It remains unclear where morbidity, mortality, and associated injuries with pelvis injuries sustained on the battlefield overlap with the civilian data. The purpose of this study was to describe pelvic fractures and their associated injuries in US military personnel who either died of wounds (DOW) or were killed in action (KIA) during Operation Iraqi Freedom and Operation Enduring Freedom and define any differences in associated injuries between penetrating versus blunt type of direct injury to the pelvis.

MATERIALS AND METHODS

A systematic review of data on all US military nonsurvivors who sustained pelvic fractures during Operation Enduring Freedom and Operation Iraqi Freedom from January 1, 2008, to December 31, 2008, was performed after institutional review board approval. The Armed Forces Medical Examiner System (AFMES) database was searched for all pelvic fractures identified in US military personnel during autopsy. Autopsy reports, electronic radiographs, and comprehensive autopsy photographs of these military personnel were reviewed. Pertinent data extracted included the following: mechanism of injury to the individual as a whole, type of direct injury to the pelvis (blunt versus penetrating), pelvic fracture classification (Tile, and Young and Burgess), and associated injuries. Mechanism of injury was separated from the type of direct injury to the pelvis, because an explosion injury to the individual may result in a blunt injury to the pelvis.²⁰ Classification of pelvic fractures as blunt or penetrating involved a regimented three-step process: chart review, autopsy photograph review, and finally,

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digital radiograph review to ensure that all three correlated with an intrapelvic or transpelvic penetrating injury before being classified as penetrating. If there was no clear evidence of an intrapelvic or transpelvic penetrating injury, the type of injury was classified as blunt. All fractures were classified by a fellowship-trained orthopedic trauma surgeon (J.R.H.).

The determination of DOW versus KIA was initially done at first point of care. As autopsy reports, photographs, radiographs, and injury records were carefully reviewed by the assembled research team, a mark was made on a Visual Analog Scale and casualties were further defined as “Not Survivable” versus “Potentially Survivable”, mimicking prior studies of military combat mortalities.²¹

All demographic factors in the study were summarized using percentages. A χ^2 test was used to compare frequencies of different factors unless the expected frequencies were <5 . In those cases, Fisher’s exact test was used. Variables deemed significant had a p value <0.05 .

Initial Handling of Those KIA/DOW

All US Department of Defense fatal casualties from Overseas Contingency Operations are received and processed through the Port Mortuary division of the Air Force Mortuary Affairs Operations Center, located at Dover Air Force Base, DE. Once the casualties arrive, they are transferred by an Honor Guard to the Mortuary Branch where they are electronically processed and forwarded to obtain a full body computed tomography scan, Federal Bureau of Investigation fingerprints, dental identification, further radiography, and autopsy.²² All autopsy data of US military personnel is recorded in the AFMES database and maintained at the AFMES division of the Armed Forces Institute of Pathology in Rockville, MD.

RESULTS

There were a total of 260 KIA and 90 DOW involving US military personnel during 2008.²³ Of those 350 service members, 104 were identified through the AFMES database as having a pelvic fracture identified on autopsy. Thirteen were excluded from the study because of absence of electronic radiographs (eight) and incorrect diagnosis (five; acetabulum fractures).

Study Group Demographics

Of the 91 US military personnel remaining, 90 were male and 1 was female. Age was documented on 84 of the 91 military personnel. Two service members were younger than 20 years, 55 were 20 years to 29 years old, 24 were 30 years to 39 years old, and three were older than 40 years. Information on mounted versus dismounted was obtained in 81 of the 91 military service members. Sixty-three were recorded as being mounted at time of injury (77.8%) and 18 were dismounted (22.2%).

Injuries

Of the 91 nonsurvivors included in this study, 70 were classified as “Not Survivable” (76.9%) and 21 as “Potentially Survivable” (23.1%) (Fig. 1). Mechanisms of injury to the

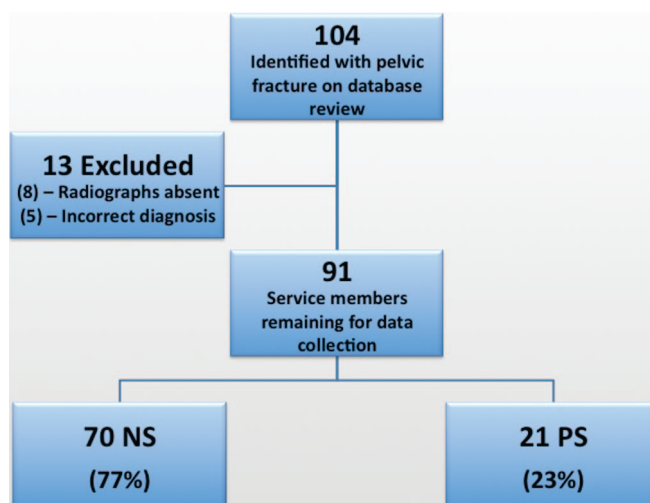


Figure 1. Graphical representation of the study population.

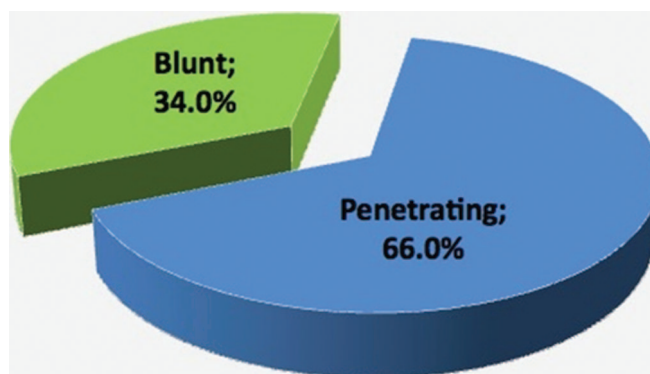


Figure 2. Pelvis injuries were frequently caused by penetrating mechanisms.

individual included the following: 69 blast (76.0%), 14 gunshot wounds (GSW) (15.0%), 4 MVCs (4.5%), and 4 “other” (4.5%).

Pelvic Injuries

With respect to type of direct pelvis injury, 60 (66.0%) of the pelvis fractures were classified as penetrating and 31 (34.0%) as blunt (Fig. 2). Twenty-four (26.4%) were classified as Tile A (stable fracture pattern), 13 (14.3%) as Tile B (partially stable, rotationally unstable), 51 (56.0%) as Tile C (rotationally and vertically unstable), and 3 (3.3%) as “unable to classify”. Twenty fractures (22.0%) were classified as Young and Burgess anterior posterior compression, 5 (5.5%) as lateral compression, 11 (12.1%) as vertical shear, 23 (25.3%) as combined mechanism, and 32 (35.1%) as unable to classify/penetrating. Large vessel injuries were identified in 40 of 91 cases (44.0%). More specifically within the pelvis, large pelvic vessel injury (internal and/or external iliac vessels) was observed more frequently in penetrating pelvic injuries (16 of 60, 26.7%) when compared with blunt injuries (1 of 31, 3.2%) ($p < 0.0001$; Table 1).

TABLE 1. Associated Intrapelvic Injuries per Type of Pelvic Fracture

	Blunt (n = 31)	Penetrating (n = 60)	<i>p</i>
Large pelvic vessel injury, n (%)	1 (3.23)	16 (26.67)	<0.0001
Genitourinary injury, n (%)	13 (41.94)	46 (76.67)	0.1419

TABLE 2. Other Associated Injuries per Type of Pelvic Fracture (in This Study Population)

	Blunt (n = 31)	Penetrating (n = 60)	<i>p</i>
Large vessel injury, n (%)	11 (35.48)	29 (48.33)	0.2418
Spine fracture, n (%)	16 (51.61)	20 (33.33)	0.0910
Spinal cord injury, n (%)	6 (19.35)	10 (16.67)	0.7495
Head injury, n (%)	21 (67.74)	27 (45.00)	0.0395
Cardiopulmonary injury, n (%)	26 (83.87)	34 (56.67)	0.0095
Intra-abdominal injury, n (%)	25 (80.65)	49 (81.67)	0.9057
Solid organ, n (%)	25 (80.65)	33 (55.00)	0.0159
Hollow viscous, n (%)	3 (9.68)	34 (56.67)	<0.0001

Italics indicate the *p* value is significant (*p* < 0.05)

Associated Injuries

Abdominal injuries were identified in 74 of 91 military members (81%), with hollow viscus injuries being more common in those with penetrating pelvic injuries (34 of 60, 57%) than blunt injuries (3 of 31, 10%) (*p* < 0.0001). There was an inverse relationship between groups in those with intra-abdominal, solid organ injuries (blunt, 25 of 31, 81%; penetrating, 33 of 60, 55%; *p* = 0.0159). Head injuries were also more common in those with blunt pelvic injuries (21 of 31, 68%) than penetrating pelvic injuries (27 of 60, 45%) (*p* = 0.0395). Similarly, cardiopulmonary injuries were more frequently identified in those sustaining blunt mechanism injuries (26 of 31, 84%) when compared with penetrating mechanism injuries (34 of 60, 57%) (*p* = 0.0095). Other associated injuries identified during autopsy included spine fractures, spinal cord injuries, and extremity fractures and/or traumatic amputations. Findings of associated injuries are summarized in Table 2.

DISCUSSION

This is the first description of battlefield pelvic fractures in nonsurvivors. While MVCs are the leading mechanism causing pelvic fractures in the civilian population, blast injuries are the most common cause on the battlefield.^{1,4–6,18} In contrast to civilian trauma, the current study showed penetrating pelvic injuries account for two-thirds of the population. Penetrating pelvic injuries in the civilian literature are predominately low velocity GSW to the hip and pelvis.²⁴ While described briefly in the literature, this is the largest cohort evaluating explosion injuries with resultant direct penetrating injuries to the pelvis during the current conflicts.²⁵

A prospective study by Giannoudis et al., evaluating associated injuries in trauma patients with pelvic fractures, demonstrated fewer associated injuries than those seen in this study, although their data also included survivors. Specifi-

TABLE 3. Comparison of Pelvic Fracture-Associated Injuries, Civilian Versus Military Trauma

	Civilian Data	Combat Related Data (Our Study)		
		Blunt	Penetrating	Total
Long bone fractures/ amputations	50.0%	83.87%	75.00%	78.00%
Head injuries	46.0%	67.74%	45.00%	52.75%
Cardiopulmonary injuries	10.8%	83.87%	56.67%	65.93%
Abdominal injuries	9.5%	80.65%	81.67%	81.32%
Aortoiliac vascular injuries	2.7%	35.48%	48.33%	43.96%

cally, the cohort of Giannoudis et al.¹ had chest trauma in 21.2%, head injury in 16.9%, and long bone fractures in 7.8% of his patients. When data were adjusted for those who died of their injuries, the incidence of head and chest trauma in the study by Giannoudis et al. was similar to that of our study, but the incidence of abdominal injuries remained one-third of that in the present study's cohort.

The closest parallel to the present study was by Rittmeister et al.,⁸ who evaluated multiple injury patients with pelvic fractures who also died of their injuries. Comparison to this cohort (Table 3) demonstrates the differences in the rates of associated injuries. Some of the largest differences exist in the categories of injuries that are potentially lethal in nature, such as cardiopulmonary injury and aortoiliac vascular injuries.

Likely due to this study's population of only fatalities, the majority of pelvic fractures were classified unstable (Tile type B 14.3% and Tile type C 56.0%). Because of the unique nature of an explosive penetrating injury to the pelvis, over one-third could not be classified. Much controversy exists in the literature as to whether pelvic fracture type is a predictor for outcome or mortality.^{1,3,5–8,10,17} Adams et al.,⁶ in a study of MVC victims with concomitant pelvic fractures found that 89% (73 of 82) of those casualties who did not survive their hospitalization had Tile type C pelvic fractures. These data were similar to other studies that drew a correlation between mortality rate and severity of fracture.^{1,5,10,17} Although the majority of this study's cohort never made it to formal care beyond self-aid, buddy aid, or the combat medic or corpsman level, the study by Rittmeister et al. on pelvic fractures in multiple injury patients who died in the hospital likely draws the closest parallel to this study's population in the existing literature. Within the cohort of mortalities of Rittmeister et al., pelvic fractures were classified as 16% Tile type A, 49% type B, and 35% type C.⁸ This study also showed a predominance of type B and C fractures, accounting for a combined percentage of 70.3% of the mortally wounded military personnel. However, even with a majority of type B and C fracture types, Rittmeister et al. still concluded that the cause of death in the polytraumatized mortalities is more a function of associated injuries based on Injury Severity Score and not severity or classification of fracture type. This observation is concordant with other published studies.^{3,7}

An important point highlighted by this study should be addressed. In pelvic fractures, reported mechanisms of injury do not always correlate with direct mechanism of injury and

should be carefully reviewed. Although the reported mechanism of injury was explosion and GSW in 91% of the cohort, after reviewing the data carefully, the direct mechanism of injury to the pelvis was actually only penetrating in two-thirds of the cases. This resulted in a change of the actual mechanism of injury from penetrating to blunt by 25%.

In this study, several key results were identified to be statistically significant. First, the majority of pelvic fractures sustained in those mortally wounded on the battlefield are the result of penetrating injuries (66%). Second, penetrating pelvic injuries were overall eight times more likely to have a large pelvic vessel injury than blunt injuries. Third, penetrating pelvic injuries resulted in nearly six times more hollow viscous intra-abdominal injuries (57%) when compared with blunt injuries (10%) but only in two-thirds the amount of solid organ injuries (55% and 81%, respectively). Finally, cardiopulmonary and head injuries were more common in blunt pelvic injuries (84% and 68%, respectively) than penetrating injuries (57% and 45%, respectively). Given the severity of these associated injuries, they likely contributed to the cause of death in each respective cohort.

The primary limitation of this study is its retrospective design. All data reviewed in charts were also cross-referenced with both autopsy photographs and full body radiographs, which nearly always included full body computed tomography scans to mitigate the inherent weaknesses of retrospective data collection. Furthermore, the date range used to collect data from was chosen specifically because of the high quality of documentation. Another limitation of this study is the inability to study the mechanism of injury in depth as it relates to explosive device, mounted versus dismounted, vehicle type, position in vehicle, and armor strategies of the vehicle. Much of these data are classified, and reporting such data are unethical to the military service members.

In conclusion, pelvic fractures sustained on the battlefield have a much different mechanism of injury than civilian trauma and have a very high rate of associated injuries. Reported mechanism of injury, specifically in pelvis fractures, does not always correlate with the actual direct injury to the pelvis. Large pelvic vessel and hollow viscous injuries occur more frequently in penetrating combat-related pelvic fractures, whereas intra-abdominal solid organ, head, and cardiopulmonary injuries are more common in blunt pelvic injuries. Further research is required to determine overall incidence of pelvic fractures in a wartime environment and factors that could affect survival of the Marines, Sailors, Soldiers, and Airmen. Hopefully, with improved technology and better understanding of injury patterns, survival will continually move toward the “Potentially Survivable” benchmark on the Visual Analog Scale and further away from “Not Survivable.”

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